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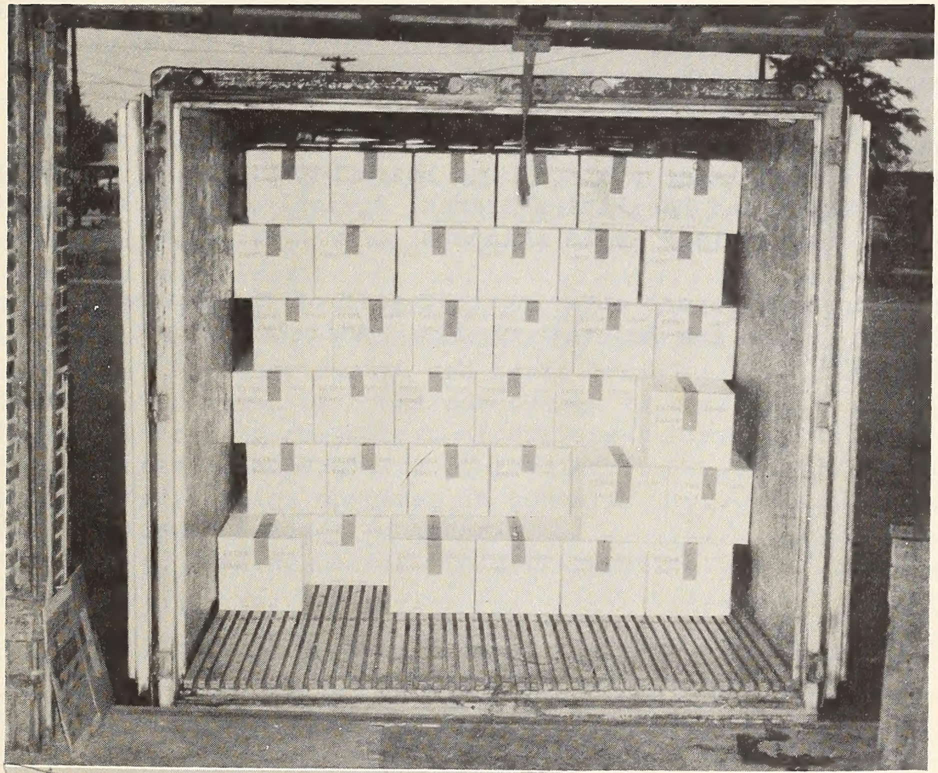
LOADING METHODS

for truck shipments of APPLES in fiberboard boxes



An Interim Report

Agricultural Marketing Service
Marketing Research Division
AMS- 321
U. S. DEPARTMENT OF AGRICULTURE
in cooperation with
Maine Agricultural Experiment Station
and Maine Department of Agriculture

PREFACE

This study of damage to McIntosh apples packed in fiberboard boxes and shipped by motortruck from Massachusetts and Maine to Florida was undertaken: (1) To determine the extent and causes of container and commodity damage in long-distance motortruck shipments of McIntosh apples in fiberboard boxes; and (2) to develop loading methods and handling practices that provide better protection for the fruit and containers during transportation.

Damage during shipment has caused waste of marketable fruit with losses to both shippers and receivers. This study is part of a broad program of research designed to reduce the cost of marketing farm products.

The research included in this project was conducted cooperatively by the Maine Agricultural Experiment Station, the Maine Department of Agriculture, and the Transportation and Facilities Branch, Agricultural Marketing Service, at the request of New England apple shippers.

This is an interim report covering that part of the research done during the 1958 shipping season for McIntosh apples. Additional test shipments will be made during 1959.

July 1959

Cover Photograph Negative No. BN-7906

ACKNOWLEDGMENTS

This study was made possible through the cooperation of Joseph P. Sullivan & Co., Ayer, Mass.; the trucking firm of L. G. DeWitt, Inc., Ellerbe, N. C.; the Fresh Products Standardization and Inspection Branch, Fruit and Vegetable Division, Agricultural Marketing Service; and the several receivers of apples at the Florida destinations.

George H. Chick, Director, Division of Markets, Maine Department of Agriculture; and Charles H. Merchant, Frederick A. Perkins, and Franklin P. Eggert, of the Maine Agricultural Experiment Station, rendered valuable assistance in the planning of the study.

The following members of the staff of the Transportation and Facilities Branch participated in the study: Field research: W. R. Black and R. H. Hinds, Jr., agricultural marketing specialist, and Kenneth Myers, transportation economist.

Statistical compilations: Kenneth Myers, transportation economist.

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HIGHLIGHTS

Test shipments of McIntosh apples in fiberboard containers by motortruck from New England origins to Florida markets revealed that better loading methods could appreciably reduce container and commodity damage and improve refrigeration of the fruit during transit.

This study involved 17 test loads in December 1957 from regular cold storage, 13 test loads in February and March 1958 from regular cold storage, and 8 test loads in April and May 1958 from controlled-atmosphere storage. In the first 35 test loads the prevailing commercial shipping practices were examined to determine the types and extent of the transit damage and to study the loading and handling methods for any improvements that could be effected. In the last three test loads from controlled-atmosphere storage, which were experimental tests, a new and revised loading pattern was used to determine whether it provides more adequate refrigeration of the commodity during transportation.

Observations of the test loads indicated that the apple boxes at the rear of the trailers on the overhang behind the tandem axle were damaged more frequently in transit than those in other locations. The two bottom layers of the last two or three stacks in the loads tended to shift back toward the rear of the trailer while the top layers of the same stacks shifted slightly forward, compressing the boxes ahead and causing container damage from crushing, squeezing, buckling, puncturing, or denting. The damage apparently was caused by vertical impacts when the vehicles passed over rough places in the road or by vibrations inherent in the vehicles during operation. This damage could be prevented to a considerable extent by the use of adjustable gates in combination with load-locking devices at the rear of the load.

The use of too many boxes of different dimensions, even for boxes containing the same number of apples, also appeared to contribute to container damage. The stacks of the loads where varying sizes of boxes were used were irregular and the loads not as compact as they should have been. An appreciable part of the container damage in the test loads obviously resulted from irregular and crosswise movement of the containers in the trailers during transit where there was a mixture of three or more different sizes of boxes. Loads of only two sizes had less damage.

Beginning with shipments of controlled-atmosphere apples in April 1958, the cooperating shipper used one box of uniform dimensions for the 80-, 96-, and 160-count apples and another of uniform dimensions for the 120- and 140-count apples. Thus the number of box sizes required was reduced from five to two. Uniformity of sizes of boxes helps to reduce container damage considerably. For example, the two new types of boxes used in eight test shipments during April and May 1958 had only 0.9 percent of container damage, compared with 2.7 percent in 13 previous test loads which contained many sizes of boxes.

The method of loading the apple boxes in the trailer is an important factor in the proper refrigeration of the load, particularly with shipments of controlled-atmosphere apples moving from Massachusetts and Maine to Florida during April and May, the warmest part of the apple shipping season. During transportation southward the apples had a tendency to become soft from progressively warmer temperatures unless adequate refrigeration was maintained.

In the three experimental shipping tests of controlled-atmosphere apples, the load patterns were revised so all the boxes in succeeding stacks of the loads were in the identical positions as those in the first stack. Thus air-channels were provided from the front to the rear of the load along each sidewall of the trailer. This, coupled with the allowance of a space of 10 to 12 inches between the rear of the load and the rear doors of the trailer, greatly increased the circulation of air, thereby facilitating more effective refrigeration during transit. Where the revised loading pattern was used, the maximum fruit temperature at destination was held to 40° to 42° F. compared with temperatures as high as 50° to 60° along the sidewalls in loads not having the air channels. Although this loading pattern seems to afford favorable results, more experimental tests with it are needed before definite conclusions on its effectiveness can be reached.

The tests also showed that the circulation of air in the trailer body is enhanced if strips are provided along the sidewalls and rear doors to keep the load from fitting too tightly against them, by having larger grooves in the floor channels, by using floor racks, by keeping the grooved floor channels free of trash and dirt especially at the front bunker area, and by inserting air vents in the apple boxes.

LOADING METHODS
FOR TRUCK SHIPMENTS OF
APPLES IN FIBERBOARD BOXES

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BACKGROUND

For some time shippers of New England-grown McIntosh apples have had considerable damage in long-distance motortruck shipments of apples in cell-pack fiberboard boxes, particularly on movements to Florida markets. Part of the damage was caused by load shifting and partial telescoping, or crushing, of the boxes in the forward parts of the loads. Additional and more serious damage appeared to have resulted from partial telescoping of the boxes in the lower layers of the stacks at the rear of the loads due to a combination of overhead weight and vertical vibration at that location.

In addition to the container damage, there has been considerable fruit bruising, to which the McIntosh variety of apple is particularly susceptible. These conditions caused waste of marketable fruit with a loss to both shippers and receivers. It was desirable that a solution to this problem be found to reduce this loss to a minimum, hold down marketing and transportation costs, and improve the quality and condition of the fruit delivered to the consumer.

METHODS OF OBTAINING TEST DATA

Observations of a general nature were made on 12 random nontest loads during a preliminary survey in Maine and Massachusetts in November 1957, including some long-haul shipments to points other than in Florida, to familiarize the project personnel with the prevailing truck transportation methods. The test shipments were begun in December 1957, with 17 truckloads of apples from regular cold storage in Maine and Massachusetts to Florida markets. The work on these December tests consisted principally of checks to determine the types and extent of transit damage and a study of the loading and handling methods, types of transportation equipment used, and methods of securing the loads. These tests provided a means for the development of any needed changes in the loading and handling practices and in the project work plan for subsequent test shipments.

1958 Test Shipments

A total of 21 test truckloads of New England McIntosh apples in regular slotted fiberboard boxes beginning with Test 18 was made from Massachusetts and Maine to Florida destinations during February, March, April, and the first part of May, 1958. Thirteen of these loads were from regular cold storage and 8 were from controlled-atmosphere storage.

The 13 test loads from regular storage included 10 from Ayer, Mass., and 3 from Turner and Sanford, Me. The 8 controlled-atmosphere storage loads consisted of 4 from Ayer, Mass., and 4 from Auburn and Turner, Me. The number of fiberboard boxes in the 13 regular storage loads ranged from 640 to 768, and averaged 711. For the 8 controlled-atmosphere storage loads the range was from 586 to 731 with an average of 665. The 21 test loads combined had an average of 694 boxes per load, ranging from 586 to 768 boxes per load.

Test Procedures

To obtain an accurate check on the fruit bruising in transit, seven placarded sample boxes were placed in each test truckload of apples at the shipping point as follows: One box in the bottom layer and one in the third or middle layer of the first stack (counting from the front of the vehicle); one box in the bottom layer and one in the third or middle layer of the middle stack (usually the eleventh); and one box in the bottom layer, one in the third or middle layer, and one in the top layer of the last stack (at the rear of load). The location of the sample boxes in different test loads in each layer of each stack could be varied crosswise of the trailer van as long as the specified stack and layer locations were adhered to.

Two types of fiberboard containers were used in the shipping tests. One container was the cell-pack box which had each apple in an individual cell and contained 80, 96, 120, 140, or 160 apples in four layers separated by fiberboard pads. There were 20, 24, 30, 35, or 40 apples per layer, depending upon the size of the boxes and the fruit (fig. 1). The other type, known as the master container, carried either one layer of nine 4-pound plastic film bags each in a separate cell or twelve 3-pound plastic film bags in three layers separated by fiberboard pads, four cells per layer with one 3-pound bag in each cell (figs. 2 and 3). The tests included apples from regular cold storage and from controlled-atmosphere storage.

The sample boxes were inspected in Maine and Massachusetts by personnel of the Federal-State Inspection Services in those States, and in Florida by personnel of the Fresh Products Standardization and Inspection Branch of the Agricultural Marketing Service, U. S. Department of Agriculture. The information obtained was recorded on special inspection forms similar to those used by the Maine Agricultural Experiment Station in a previous study of apple containers. 1/

After inspection of the sample boxes at the shipping point, any bruised fruit found in the sample-box cells or plastic film bags designated on the recording forms was replaced with bruise-free fruit from nonsample cells or bags in the same or other containers. At destination all the fruit in each sample box, including that in both the sample and nonsample cells or bags, was inspected. The bruising data resulting from the inspections at origin and destination were entered on the special inspection forms by cell or bag

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1/ Perkins, F. A. Apple Marketing Study for 1957. Maine Agr. Expt. Sta., Univ. Maine, Dept. Agr. Econ., April 26, 1957.

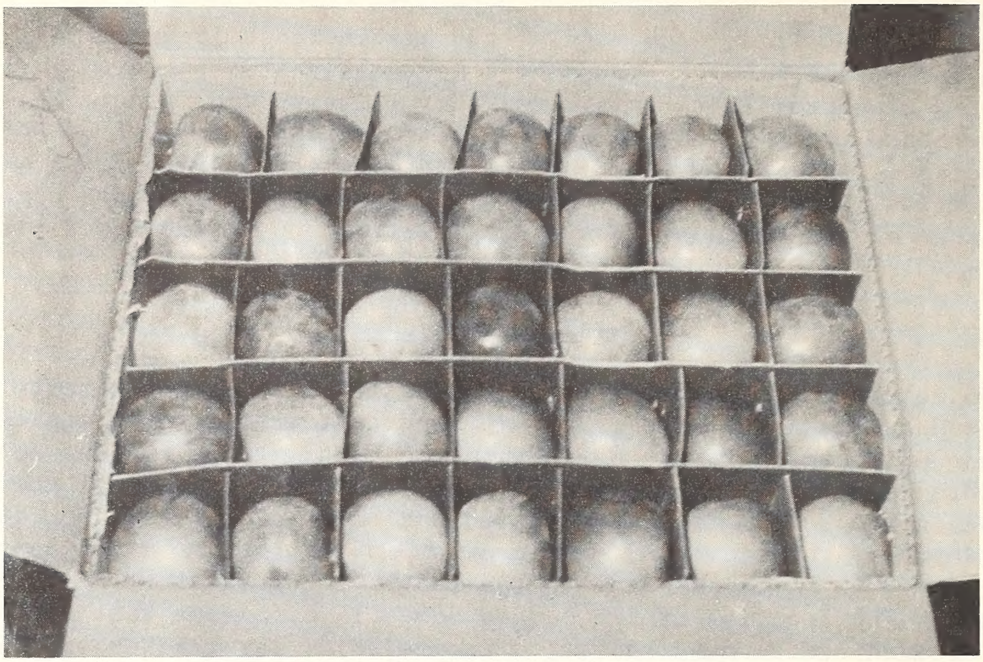

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Figure 1.--Top layer of individual cells in 140-count fiberboard box containing four layers of 35 apples each.

location with the type of bruising affecting the areas of the apples identified by cell or bag location. The forms also provided for the supplementary recording by the inspectors of internal breakdown and decay and the degree of the firmness of the fruit.

An origin loading report provided information on the shipper, origin, and date and time of shipment; the type, condition, and protective services of the trailer; the load pattern, count, and weight; handling methods and tie-down devices; outside and commodity pulp temperatures; type, dimensions, weights, and condition of containers; and the variety, brand, and grade of fruit and the size of the pack.

At the destination, information was developed on the condition of the trailer, protective services, and handling methods used; load condition, shift or slack; outside and commodity temperatures; condition, dimensions, and types of containers; types, location, and apparent cause of container damage; and condition of the fruit.

The amount of backward or forward movement of the rear stacks of the test loads in transit was determined by placing a strip of masking tape or a heavy crayon mark vertically on each sidewall of each trailer marking the position of the rear stack or end of the load as originally loaded. Any deviation of the load from the marked position found at the destination indicated the extent of the shift of the rear stacks.

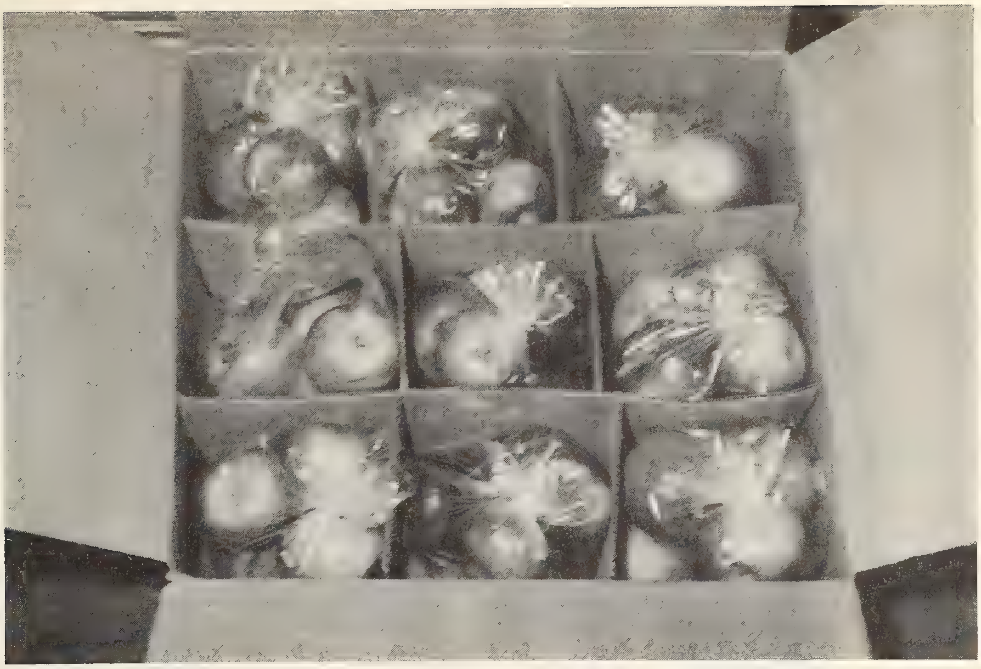

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Figure 2.--Top view of 1-layer, 36-pound master fiberboard box of apples containing nine cells with one 4-pound plastic film bag in each cell.

U. S. Department of Agriculture seals were applied to the door hasps of each test trailer after loading. This made it possible to ascertain at destination if the trailer doors had been opened in transit for purposes of rearranging the test loads. Thus, it could be determined whether such rearrangement contributed to any damage to the lading.

The boxes in all of the test loads were loaded upright on bottoms, lengthwise and crosswise. The crosswise offset loading pattern was most generally used. The loads were usually 5 or 6 boxes high with several loads running 4 high and two loads 7 high. The loading pattern depended upon the size of the boxes shipped, the loading requirements, and the space available in the trailer.

The controlled-atmosphere storage apples in the test shipments came from airtight refrigerated warehouses in which the percentages of carbon dioxide and oxygen are closely regulated. The atmosphere in the airtight storage rooms is adjusted to contain about 4 to 5 percent carbon dioxide rather than the usual 0.3 percent and 2.5 to 3 percent oxygen instead of the normal 21 percent.

The various loading patterns were carefully examined to determine what modifications would be required to provide improved loading methods and safer transportation.

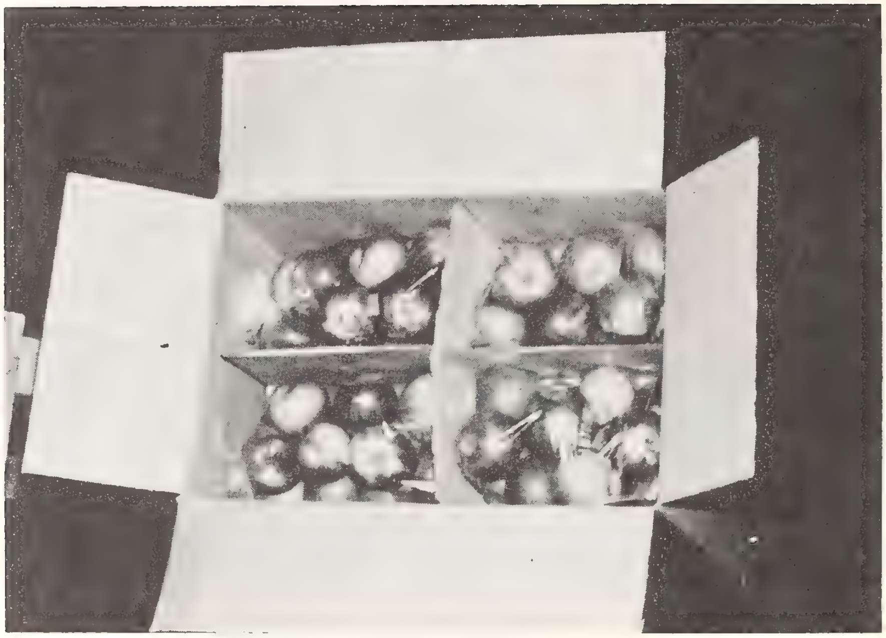

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Figure 3.--Four-bag layer of 36-pound master fiberboard box of apples containing twelve 3-pound plastic film bags in three layers of four cells with one bag to a cell.

During the movement of apples from controlled-atmosphere storage warehouses in April and May 1958, the commodity temperatures in one box from the center and from the side of the bottom, middle, and top layers in six or seven stacks of two test loads were checked at origin. These boxes were appropriately marked so the commodity temperatures could be taken at destination.

EVALUATION OF LOADING AND RELATED HANDLING METHODS

Extent of Container Damage and Fruit Bruising

The container damage occurring in the 21 test loads from Maine and Massachusetts, analyzed in table 1, is based on inspections at the Florida destinations by personnel of the Transportation and Facilities Branch.

The 13 test loads from regular storage had a total of 247 damaged boxes or an average of 19 boxes per load. The damage for the 13 loads amounted to 2.7 percent of the total 9,242 boxes.

Table 1.--Fiberboard boxes damaged in test shipments of McIntosh apples during transit by motortruck from Mass. and Me. origins to Fla. destinations by type and extent of damage, February-May, 1958 1/

Description of loads and location of container damage	Number of damaged containers by type and extent of damage 2/																																
	Crushed			Compressed or squeezed			Creased			Bulged or buckled			Punctured or dented			Cut or torn			Sprung or open			Spilled (part out)			Ice water damage			Others			All containers			
	S	M	H	S	M	H	S	M	H	S	M	H	S	M	H	S	M	H	S	M	H	S	M	H	S	M	H	S	M	H	S	M	H	Total
13 loads from regular storage during February and March:																																		
Covers (tops)	-	3	-	6	1	-	8	-	-	1	-	-	7	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	26	4	-	30
Bottoms	-	2	-	1	5	-	a/5	-	-	a/19	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	b/31	30	-	-	-	29	38	30	97
Ends	-	-	1	4	-	-	2	-	-	1	-	-	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	18	-	1	19
Sides	-	-	-	7	-	1	16	-	-	33	-	-	28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	c/4	-	-	88	-	1	89
Corners	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	2	-	-	1	-	-	-	-	-	-	-	-	d/4	-	-	12	-	-	12
Total	-	5	1	18	6	1	36	-	-	54	-	-	50	-	-	6	-	-	1	-	-	-	-	-	-	31	30	8	-	-	173	42	32	247
Average per load																															13.3	3.2	2.5	19
8 loads from controlled atmosphere storage during April and May:																																		
Covers (tops)	-	-	-	-	-	-	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	-	8
Bottoms	-	-	-	14	-	1	3	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19	-	1	20
Ends	-	-	-	-	-	-	-	-	-	-	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	-	14
Sides	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	6
Corners	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
Total	-	-	-	14	-	1	3	8	-	8	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	25	22	1	48
Average per load																															3.1	2.8	0 1	6
All 21 test loads combined:																																		
Covers (tops)	-	3	-	6	1	-	8	8	-	1	-	-	7	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	26	12	-	38
Bottoms	-	2	-	15	5	1	8	-	-	21	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	31	30	-	-	-	48	38	31	117
Ends	-	-	1	4	-	-	2	-	-	1	14	-	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	18	14	1	33
Sides	-	-	-	7	-	1	16	-	-	39	-	-	28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	c/4	-	-	94	-	1	95
Corners	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	2	-	-	1	-	-	-	-	-	-	-	-	d/4	-	-	12	-	-	12
Total	-	5	1	32	6	2	39	8	-	62	14	-	50	-	-	6	-	-	1	-	-	-	-	-	-	31	30	8	-	-	198	64	33	295
Average per load																															9.4	3.0	1.6	14

1/ Apparent causes of damage in order of frequency of occurrence:

1. Overhead weight and vertical load vibration
2. Failure of loading devices to hold loads tightly in place
3. Poor load arrangement
4. Load shift
5. Load slack
6. Road impacts
7 Moisture
8. Handling during loading

2/ S - Slight damage
M - Moderate damage
H - Heavy damage
a/ - Also ends
b/ - Also sides
c/ - Rubbed
d/ - Loose staples

There were 48 damaged boxes in the 8 test loads from controlled-atmosphere storage, an average of 6 boxes per load. The damaged boxes constituted only 0.9 percent of the total of 5,325 boxes in these 8 test loads.

The 295 damaged boxes in the combined 21 test loads averaged 14 boxes per load and represented 2 percent of the total of 14,567 boxes in these loads. The principal types of container damage were: Compression or squeezing, creasing, bulging or buckling, puncturing or denting, and wetting from ice water leaks in the trailer ice bunkers. Of the 295 damaged boxes, 274 were in these damage categories. Although 2 percent container damage is not considered an excessive amount, even less would be desirable.

The causes of the transportation damage to the containers, according to frequency of occurrence were: Overhead weight of boxes coupled with vertical load impacts or vibration; failure of load-securing devices to hold the load in place tightly; poor load arrangement, some of which was due to irregular loading patterns from mixing nonuniform sizes of boxes in the same load; load shift from too much load slack; impacts from over-the-road operation of trailers; moisture absorption by boxes; and rough handling of boxes during loading of the trailers.

The comparative amount of commodity bruising at origin and destination in 12 test loads of McIntosh apples out of regular storage from Massachusetts and Maine origins to Florida destinations during February and March 1959 appears in table 2. These data were developed from inspection by the Federal-State Inspection Service in Massachusetts and Maine and by the USDA Fresh Products Standardization and Inspection Service at destination.

The cell-pack fiberboard boxes in the 12 loads, on the basis of the inspection of all sample boxes combined, averaged 12 percent slight bruising (not affecting grade), 1.8 percent damage by bruising, and 0.3 percent serious bruising at origin. At destination the corresponding percentages were 17.6, 8.3, and 4 percent. Thus there were increases in the bruising averages at destination of 5.6 percentage points for slight bruising, 6.5 percentage points for damage by bruising, and 3.7 percentage points for serious bruising, most of the latter consisting of punctures from the stems of other apples.

Examination of the sample boxes showed bruising at origin in the master fiberboard boxes containing plastic film bags of apples averaged 2.1 percent slight bruising (not affecting grade), 1.1 percent damage by bruising, and 0.5 percent serious bruising. At destination the corresponding averages were 21.6, 11, and 26.9 percent, increases of 19.5, 9.9, and 26.4 percentage points compared with the averages at origin. Stem punctures comprised the major part of the serious bruising.

The increases in bruising rates at destination over the bruising rates at origin, expecially serious bruising, were much greater for the master boxes containing plastic film bags of apples than for the cell-pack boxes in which each apple is packed tightly in an individual paperboard cell. The apples could not be tightly packed in the plastic film bags because of the irregular sizes of the fruit. Usually the filled bags did not reach the top of the master fiberboard box. The resulting looseness of pack caused the

Table 2.--**Bruising** of McIntosh apples in 12 test loads shipped by motortruck from regular storage in Mass. and Me. to Fla. destinations by location in load and type of container during February and March 1958

Location of sample boxes in trucks 1/	Inspection point	**Cell** pack fiberboard boxes 2/			Plastic-film bags in master fiberboard boxes 5/		
		Damage by: Slight bruising 3/	Damage by: bruising	Damage by: Serious bruising 4/	Damage by: Slight bruising 3/	Damage by: bruising	Damage by: Serious bruising 4/
		Percent	Percent	Percent	Percent	Percent	Percent
Bottom layer of stack at bunker end	Origin	14.8	4.2	0.3	2.1	1.0	1.6
	Destination	19.8	4.6	3.4	7.7	4.0	29.6
Middle layer of stack at bunker end	Origin	15.1	2.5	0	1.5	.5	0
	Destination	22.4	11.6	3.6	6.3	7.0	26.3
Bottom layer of stack at half-length	Origin	9.8	1.3	.3	4.2	2.8	.7
	Destination	11.2	3.0	4.2	27.3	8.2	16.7
Middle layer of stack at half-length	Origin	6.6	2.2	0	2.9	1.6	.7
	Destination	13.8	4.8	4.2	23.3	7.0	18.4
Bottom layer of stack at rear door	Origin	12.5	.3	.3	0	0	0
	Destination	18.0	11.2	4.2	30.0	12.6	17.1
Middle layer of stack at rear door	Origin	11.7	1.4	.5	0	1.0	0
	Destination	18.0	11.2	4.2	28.6	20.5	37.7
Top layer of stack at rear door	Origin	13.4	1.1	.4	3.2	0	0
	Destination	20.0	11.6	4.0	27.5	17.6	43.6
All locations combined	Origin	12.0	1.8	.3	2.1	1.1	.5
	Destination	17.6	8.3	4.0	21.6	11.0	26.9

1/ Under test procedure sample boxes were placed in each truckload in the bottom and middle layers of the first stack (bunker end); in the bottom and middle layers of the stack at half-length of the trailer; and in the bottom, middle, and top layers of the last stack at the rear doors.

2/ Based on 11 loads on which sufficient test data were obtained.

3/ Not affecting grade.

4/ Serious bruising was mostly stem punctures.

5/ These plastic-film bag loads were mixed loads with the loads referred to under 2/, except for one solid load of plastic film bags in master containers.

apples in such bags to be more susceptible to damage from handling and transportation jolts and impacts. This accounted in a large measure for the greater increase in the bruising rates for the apples in plastic-film bags in the master boxes than for the apples in cell-pack boxes.

The inspections at destination revealed that some of the cell-pack boxes of 120- and 140-count apples in several test loads did not have bottom pads. As a result, the protruding staples in the bottom flaps of the boxes punctured and seriously bruised the bottom layers of apples, especially during transit when the boxes were subjected to transportation impacts and vibrations transmitted to them by the movement of the trailer over the road.

Other conditions which may have contributed to some degree of bruising damage were: (a) Grading operations at the packinghouse; (b) the amount of pressure to which the fruit was subjected during packing; (c) excessive overhead weight from stacking boxes too high on pallets in the warehouse or too high in the trailer loads; (d) unnecessary roughness in handling the boxes during loading into the trailers; and (e) rearrangement of the loads in transit by the truck drivers.

Principal Location of Container Damage in Trailers

Damage to the apple boxes in transit was most prevalent at the rear of the trailer on the overhang behind the tandem axles. It is in this area that most of the force of the vertical impacts from the trailer passing over bumps and rough places in the road is concentrated. Generally, the two bottom layers of the last two or three stacks in the load had a tendency to shift back toward the rear of the trailer while the top layers of the same stacks shifted slightly forward compressing the boxes ahead. This forward movement probably resulted from a tightening up of a slight slack existing at the time of loading (fig. 4). The forward shifting of the upper layers caused the boxes in those layers of the rear stack to pull away from the load-locking devices behind and thus where this occurred the load locks were ineffective in holding the upper layers tightly in place.

The backward shifting of the bottom layers of the last stack can be prevented by adequate bracing in the space between the end of the load and the rear door. This bracing eliminates the voids between boxes in the lower two layers of the last three stacks into which the boxes of the upper layers can tilt and become damaged. Figure 5 illustrates the forward movement of the top layers of the rear stacks and also a simple and inexpensive method of preventing the lower layers from moving toward the rear door and blocking the circulation of air.

Another efficient and economical method of bracing the rear of a load involves the use of an adjustable endgate with load locking devices behind it as shown in figure 6. A removable gate covering the entire rear of the load with load locks behind it would also have been effective in keeping the load from shifting back toward the rear doors.

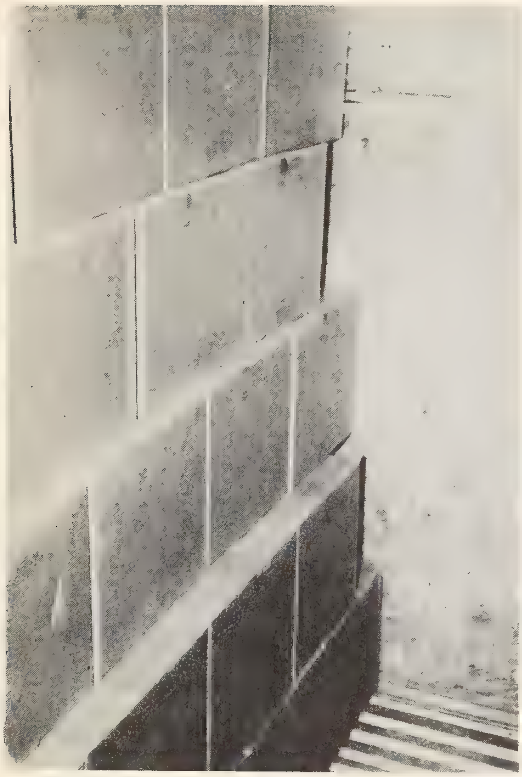

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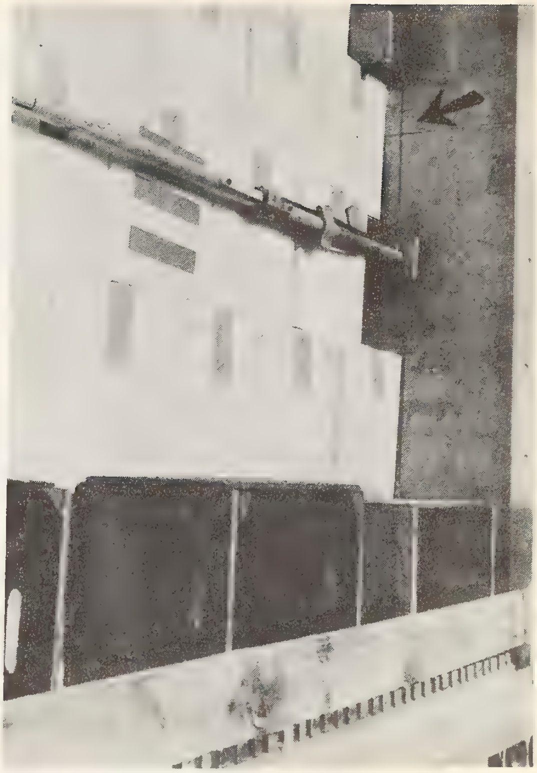
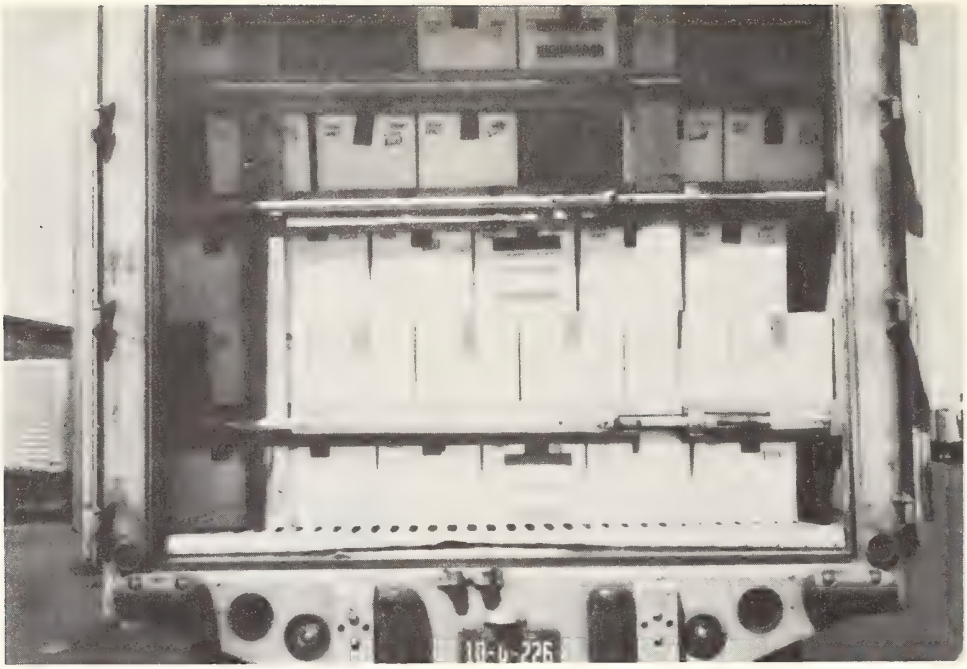
Figure 4.--One of rear stacks of a test load showing shift of two bottom layers of boxes toward rear of trailer and shift of upper three layers forward.



BN-7911

Figure 5.--Rear of test shipment showing use of a 1-inch thick board behind three wooden boxes between bottom of rear stack and rear doors of trailer to prevent shift of lower layers of stacks toward rear doors and blocking of air circulation. Crayon mark (see arrow) marks orignial position of layers at time of loading which shifted toward front of trailer.

There were several instances where the boxes in the rear stacks of the trailer were loaded with their longest dimension crosswise of the vehicle. Boxes so loaded had a greater tendency to fall back against the rear door than boxes loaded lengthwise. In one or two loads the boxes loaded crosswise in the rear stacks were loosely stacked in an attempt to fill out the stacks with less than the normal number of boxes per stack, leaving considerable lateral slack at one side of the trailer (fig. 7). This caused the boxes to shift, even with the load locks in place, with some damage to the containers. To prevent damage the loose stacks should have been placed farther forward in the trailer, and all boxes in the rear stacks should have been fitted tightly against each other and loaded across the trailer so there could have been no lateral movement and shifting in this part of the load.



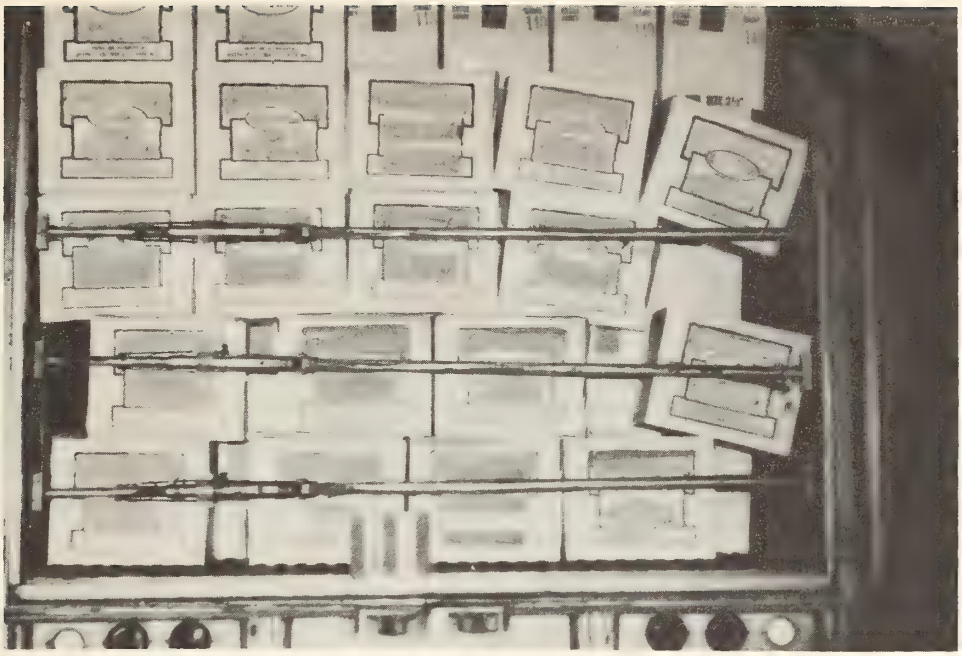
BN-7912

Figure 6.--Rear of test load showing efficient and economical bracing consisting of two 1-inch thick upright boards and three 1-inch thick crosswise boards with a load lock behind each of the latter to hold load in place.

There would have been less likelihood of damage to the master boxes of nine 4-pound or twelve 3-pound plastic film bags of apples if they had been loaded in the middle or forward part of the trailer, where there was less jolting of the load, instead of at the rear of the trailer, where the vertical vibrations are of greater intensity. The apples in the plastic film bags were jumble packed and loose and did not always completely fill the bags because of the irregular sizes of fruit. The apples in these bags had a tendency to rotate when subjected to continuous vibration from the vehicle motion. Since the bags did not fill the large cells in the master boxes completely, these boxes were not so rigid a package as the regular cell-pack boxes, such as those of the 120- and 140-count boxes, and their flexibility contributed to more fruit bruising and container damage, especially when loaded in the rear of the trailer.

Effect of Loading Containers of Different Sizes

Generally, the receivers were well pleased with the condition of the test loads of apples on arrival. Some, however, said there were too many boxes of different dimensions even for the boxes containing the same number of apples. The mixing of irregular size boxes resulted in loose loads which contribute to container damage.



BN-7913

Figure 7.--Rear view at destination of the last stack of 140-count cell-pack boxes with their longest dimension crosswise of the trailer. This produced too much crosswise slack which permitted the boxes to shift during transit, even with load locks in place.

An appreciable part of the container damage occurring in the test shipments resulted from crosswise shifting in the loads in which there were three or more different sizes of boxes. The loads which contained only two sizes of boxes had less damage. The receivers also preferred boxes of uniform outside dimensions to better facilitate handling and stacking.

The number of different size boxes was reduced by the cooperating shipper when the controlled-atmosphere apple shipments began in April 1958. In those shipments a new type of box was used which had no side inner-liners. The box, however, was equipped with top and bottom pads and pads between the layers--a total of five pads. One box of uniform dimensions was used for the 80-, 96-, and 160-count apples and another of uniform dimensions for the 120- and 140-counts; the spacers or cells were adjustable to fit the size of apple intended for each box. Thus the number of box sizes previously required for these counts of apples was reduced from five to two.

The new sizes of boxes were used in the 8 test shipments of controlled-atmosphere storage apples from April 11 to May 2, 1958, and the inspection reports at destination indicated the boxes arrived with little or no damage. It appears, therefore, that the use of fewer types of boxes with more uniform dimensions lessens transit damage to the containers through more uniform loading patterns with better fitting loads.

Need for Closer Supervision of Loading

Observations at the shipping points indicated that closer supervision of loading of the trailers by the shipper and more systematic arrangement of the shipper's loading orders to the truck drivers would contribute to greater uniformity of loads, better loading methods, and more efficient handling. For example, in one test load of 20 stacks, all stacks except the 14th contained fiberboard boxes of apples arranged as follows: the first 4 stacks contained 120-count boxes; the 5th and 6th stacks, 160-count boxes; the 7th and 8th stacks, 140-count boxes; the 9th stack, a mixture of 140- and 120-count boxes; the 10th stack, a mixture of 120- and 100-count boxes; the 11th stack, 100-count boxes; the 12th stack, a mixture of 100- and 80-count boxes; the 13th stack, 80-count boxes; the 14th stack, wooden boxes; the 15th through the 18th stacks, a mixture of 140- and 120-count boxes; and the rear 2 stacks, 100-count boxes.

Containers with dissimilar dimensions were mixed in the same stacks and throughout the load. This shipment was loaded at two cold storage warehouses in two widely separated parts of the origin point, some boxes of each count having been loaded at each warehouse. Such an irregular load, in which the stacks do not come out evenly and do not fit compactly, cannot be properly secured and has too much lateral slack. Therefore, it is more susceptible to damage, especially container failure, than if the boxes of similar size were placed together instead of interspersed throughout the trailer.

If the shipper arranged his loading orders so the boxes of similar size and count were loaded together and compactly, the adverse loading conditions of the mixed-box-size load could have been eliminated. This would provide a load less susceptible to damage as well as a reduction in the loading time. It appears that the shipper depended too much on the truck driver to load properly. A considerable amount of time was lost by the drivers by having to stop to plan how to properly and safely stow an irregular load of containers of many different sizes. The containers were thus subjected to more handling than was necessary, resulting in additional bruising to the apples and some container damage. This situation might be corrected by more careful supervision of the loading by an experienced employee of the shipper.

Lack of Ventilation Openings in Boxes

None of the fiberboard apple boxes used in the test loads had ventilation openings. They were all regular slotted boxes, the top flaps usually sealed together with a strip of heavy sealing paper. If the boxes had ventilation openings in each end, the apples could be refrigerated more effectively in transit, especially during the warmer part of the apple shipping season. This is especially important with controlled-atmosphere storage apples, which are shipped in April and May. Also, as the controlled-atmosphere storage apples move by truck southward toward the Florida destinations their degree of firmness decreases rapidly, and their susceptibility to bruising increases from the progressively warmer temperatures unless adequate refrigeration is maintained. The ventilation openings in the boxes would permit greater circulation of air to the fruit and thus provide better refrigeration during transit.

A new injury related to inadequate ventilation of apples was reported in the 1957 marketing season to have occurred on McIntosh apples stored in controlled-atmosphere storages and later packed and transported to market in cell-pack fiberboard boxes. The injury appeared most serious in motortruck shipments transported approximately 1,500 miles. This shipping injury developed from an abrasive action between the surface of the apple and the container or cell walls in combination with certain unknown factors which occurred in controlled-atmosphere storages. The visible effects were a light to very dark brown discoloration of the apple skin somewhat resembling a burned spot. The most serious damage was generally circular, ranged from 1/8 to 3/4 inch in diameter, and appeared on the apple where it came in direct contact with the container or cell walls. Loosely packed apples, which were free to rotate during transit, developed the injury in the form of a ring or complete band around the circumference. It was said the injury could become serious enough to prove very costly to McIntosh growers and handlers.

Personnel of the Agricultural Experiment Station, University of Maine, made a study of this new injury to controlled-atmosphere storage McIntosh apples and reported the following preliminary findings in June 1958:

> Apples which were packed and sealed immediately upon opening the storage rooms were most susceptible to the injury. Apples packed on succeeding days following room opening tended to show a steadily decreasing amount of damage.
>
> Cartons which were packed and sealed without sufficient ventilation appeared to show more of the injury than did adequately ventilated cartons. The injury also appeared to be most serious on over-matured fruit, but sufficient evidence is lacking to support this theory adequately.
>
> From the results of the preliminary study it appears that inadequate ventilation of controlled-atmosphere storages prior to packing operations may be one factor responsible for this shipping "burn" injury. The isolation of this injury under controlled conditions has provided extremely valuable information. Further investigation and testing is necessary to provide additional information before more definite conclusions can be drawn. 2/

This study of shipping "burn" injury has indicated the desirability of having ventilation openings in fiberboard boxes, especially for apples from controlled-atmosphere storages.

2/ Perkins, F. A. and Johnson, R. A., A New Injury on McIntosh Apples Out of Controlled Atmosphere Storage, Maine Farm Research Quarterly, July, 1958, Maine Agr. Expt. Sta., Univ. of Maine.

Rearrangement of Loads in Transit

On some of the test shipments the drivers rearranged the loads in transit to redistribute the weight to comform with State weight regulations. The removal of USDA seals on the side and rear doors of the test trailers after departure from the shipping points showed that several shipments had been opened en route.

After rearrangement, the loads sometimes were not as compact as before and the resulting slack and looseness of the loads contributed to the possibility of damage to the containers and the fruit. Also, opening the trailers to adjust the loads en route interfered with adequate refrigeration of the loads, especially during warm weather. The use of proper loading patterns would eliminate the necessity for opening the trailers during transit, thus avoiding possible damage to the lading and insuring more effective maintenance of refrigeration.

Relation of Loading Pattern to Refrigeration

The eight test shipments of controlled-atmosphere storage apples from Massachusetts and Maine to Florida, Tests 30 through 37, moved from April 11 to May 2, 1958, the warmest part of the apple shipping season. Detailed observations of the fruit temperatures of these particular loads were made to determine the extent of the refrigeration in transit (table 3). In some of the loads fruit temperatures upon arrival at destination were not satisfactory. Apparently this was not due to a lack of proper refrigeration equipment on the test vehicles, but rather to the methods of stacking the boxes in the vehicle, which restricted the air circulation around the loads. All of the test loads of controlled-atmosphere apples, except Test 36, were mechanically refrigerated. The vehicle for Test 36 used water ice with blowers to circulate the refrigerated air. This trailer had only 1½ inches of insulation, while those used for the other tests had 3 to 4 inches. The thermostats on the mechanically refrigerated loads were generally set at 38° F. on departure from the point of origin except on Test 37 where the setting was for 36°

The boxes in Tests 30 through 34 were generally loaded by the crosswise offset loading method with the longest dimensions of the boxes lengthwise of the vehicle. 3/ The first box of the first (bottom) layer of the first stack next to the trailer bunker bulkhead was loaded in the corner tightly against the bulkhead and one sidewall of the trailer. The succeeding boxes of the

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3/ There were some slight deviations from the crosswise offset principle in several of the stacks in Tests 31 and 32 to obtain fuller loads. For example, in the last 2 stacks of Test 31, 4 rows of the boxes were loaded with the longest box dimensions lengthwise of the trailer and 1 row with the longest box dimension crosswise of the trailer as shown in figure 9. This resulted in a solid stack as contrasted with a crosswise offset stack depicted in figure 8.

Table 3.--Temperatures of McIntosh apples in test shipments from controlled-atmosphere storage, at point of origin in New England and at Florida markets, April and May 1958

Load description						Stack number of load 1/	Fruit temperatures (° F.)																	
Test No.	Type of refrigeration	Sidewall lengthwise air passages in load	Space between rear of load and trailer rear doors	Outside temperature (° F.)			Top layer				Middle layer				Bottom layer				Maximum		Minimum		Average	
							Center 2/		Side 3/		Center 2/		Side 3/		Center 2/		Side 3/							
				Orig.	Destn.		Orig.	Destn.	Orig.	Destn.	Orig.	Destn.	Orig.	Destn.	Orig.	Destn.	Orig.	Destn.	Orig.	Destn.	Orig.	Destn.	Orig.	Destn.
30	Mechanical (thermostat set at 38° F.)	None	None	36	70	1	4/	42	4/	46	4/	4/	4/	4/	4/	44	4/	50	-	50	-	42	-	46
						10	4/	44	4/	48	4/	4/	4/	4/	4/	43	4/	52	-	52	-	43	-	47
						22	4/	43	4/	44	4/	4/	4/	4/	4/	45	4/	51	-	51	-	43	-	46
						Av.	-	43	-	46 (53)	-	-	-	-	-	44	-	51 (56)	-	48	-	43	-	46
31	Mechanical (No record of thermostat setting)	None	None	35	76	1	4/	39	4/	42	4/	4/	4/	4/	4/	50	4/	53	-	53	-	39	-	46
						11	4/	50	4/	58	4/	4/	4/	4/	4/	42	4/	49	-	58	-	42	-	50
						22	4/	54	4/	56	4/	4/	4/	4/	4/	49	4/	54	-	54	-	49	-	53
						Av.	-	47	-	52 (56)	-	-	-	-	-	47	-	52 (60)	-	55	-	43	-	50
32	Mechanical (thermostat set at 38° F.)	None	None	46	70	1	4/	46	4/	50	4/	4/	4/	4/	4/	46	4/	50	-	50	-	46	-	48
						5	4/	46	4/	50	4/	47	4/	54	4/	46	4/	54	-	54	-	46	-	50
						10	4/	49	4/	51	4/	44	4/	55	4/	45	4/	54	-	55	-	44	-	40
						15	4/	45	4/	49	4/	46	4/	52	4/	45	4/	54	-	54	-	45	-	49
						20	4/	49	4/	54	4/	42	4/	44	4/	45	4/	52	-	54	-	42	-	48
						25	4/	46	4/	52	4/	48	4/	53	4/	54	4/	53	-	54	-	46	-	51
						Av.	-	47	-	51 (58)	-	45	-	52	-	47	-	53 (60)	-	54	-	45	-	49
33	Mechanical (thermostat set at 38° F.)	None	12 inches	69	74	1	4/	35	4/	38	4/	36	4/	35	4/	36	4/	37	-	38	-	35	-	36
						5	4/	37	4/	38	4/	41	4/	39	4/	42	4/	41	-	42	-	37	-	40
						9	4/	35	4/	36	4/	41	4/	43	4/	42	4/	46	-	46	-	35	-	41
						13	4/	36	4/	45	4/	41	4/	42	4/	41	4/	45	-	45	-	36	-	42
						17	4/	34	4/	39	4/	39	4/	48	4/	40	4/	49	-	49	-	34	-	41
						21	4/	38	4/	39	4/	39	4/	39	4/	39	4/	40	-	40	-	38	-	39
						Av.	-	36	-	39 (47)	-	40	-	41	-	40	-	43 (55)	-	43	-	36	-	40
34	Mechanical (thermostat set at 38° F.)	None	None	62	80	1	4/	46	4/	48	4/	43	4/	50	4/	38	4/	46	-	50	-	38	-	45
						5	4/	36	4/	42	4/	40	4/	40	4/	41	4/	46	-	46	-	36	-	41
						10	4/	40	4/	43	4/	44	4/	50	4/	46	4/	57	-	57	-	40	-	47
						14	4/	34	4/	44	4/	42	4/	55	4/	44	4/	56	-	56	-	34	-	46
						18	4/	33	4/	42	4/	45	4/	49	4/	46	4/	50	-	50	-	33	-	44
						22	4/	34	4/	37	4/	34	4/	43	4/	52	4/	52	-	52	-	34	-	42
						Av.	-	37	-	43 (49)	-	41	-	48	-	45	-	51 (59)	-	52	-	36	-	44
35	Mechanical (thermostat set at 38° F.)	Air passages (also wall strips)	2 inches	59	75	1	4/	40	4/	42	4/	40	4/	5/ 42	4/	42	4/	5/ 40	-	42	-	40	-	41
						4	4/	39	4/	5/ 40	4/	41	4/	5/ 40	4/	40	4/	5/ 41	-	41	-	39	-	40
						8	4/	40	4/	42	4/	40	4/	5/ 40	4/	40	4/	5/ 40	-	42	-	40	-	40
						13	4/	40	4/	5/ 40	4/	41	4/	5/ 38	4/	42	4/	5/ 39	-	42	-	38	-	40
						18	4/	38	4/	40	4/	42	4/	6/ 36	4/	40	4/	5/ 40	-	42	-	36	-	39
						22	4/	34	4/	37	4/	36	4/	35	4/	36	4/	37	-	37	-	34	-	36
						Av.	-	39	-	40 (41)	-	40	-	39	-	40	-	40 (42)	-	41	-	38	-	40
36	Water ice (bunker) (trailer iced to 3/4 full upon leaving origin)	Air passages	12 inches	58	78	7/ 1	40	50	39	54	39	44	39	49	39	44	39	50	40	54	39	44	39	49
						7/ 5	39	56	39	52	38	45	39	48	39	46	39	50	39	56	38	45	39	50
						7/ 9	39	52	39	50	39	45	38	47	38	46	39	50	39	52	38	45	39	48
						8/14	40	47	39	48	38	43	40	46	38	43	39	47	40	48	38	43	39	46
						8/17	39	47	38	50	39	46	38	50	40	46	39	47	40	50	38	46	39	48
						8/19	41	50	42	48	42	48	40	48	41	50	43	49	43	50	40	48	42	49
						Av.	40	50	39	50 (56)	39	45	39	48 (59)	39	46	40	49 (59)	40	52	39	46	39	48
37	Mechanical (thermostat set at 36° F.)	Air passages	12 inches	72	77	7/ 1	37	40	36	42	36	41	36	41	38	41	37	40	38	42	36	40	37	41
						7/ 5	35	39	36	40	35	38	34	40	32	40	34	41	36	41	32	38	34	40
						7/ 9	36	38	36	39	37	39	35	40	37	40	37	41	37	41	35	38	36	39
						9/11	38	40	37	42	35	40	38	40	39	40	37	40	39	42	35	40	37	40
						9/15	37	39	36	39	36	37	37	38	37	40	38	39	38	40	36	37	37	39
						9/17	36	40	36	40	37	40	38	41	36	40	36	39	38	41	36	39	36	40
						9/21	38	39	38	40	37	40	39	40	39	40	36	40	39	40	36	39	38	40
						Av.	37	39	36	40 (45)	36	39	37	40	37	40	36	40 (46)	38	41	35	39	36	40

1/ All stacks unloaded at same destination except as otherwise indicated. Highest numbered stack shown is last or rear stack of load, as stacks are numbered from front of vehicle.

2/ All temperatures in this column are from center of boxes.

3/ All temperatures in this column are from center of boxes against trailer sidewalls except as otherwise indicated by reference marks or ( ). Temperatures in ( ) are the averages of temperatures taken in the corner of 3 or 4 random sample boxes each in the top, middle, or bottom layers of each load where the corner of the box was tight against the plywood sidewall of the trailer and thus the fruit was susceptible to more heat infiltration than fruit in the center of the box.

4/ No temperatures taken.

5/ Temperature from center of boxes alongside air channel; i.e., there was air space of 6 inches between trailer sidewall and box.

6/ Temperatures from center of box against trailer sidewall strips, i.e., wooden strip between box and sidewall.

7/ Unloaded at Miami, Fla.

8/ Unloaded at Tampa, Fla.

9/ Unloaded at Jacksonville, Fla.

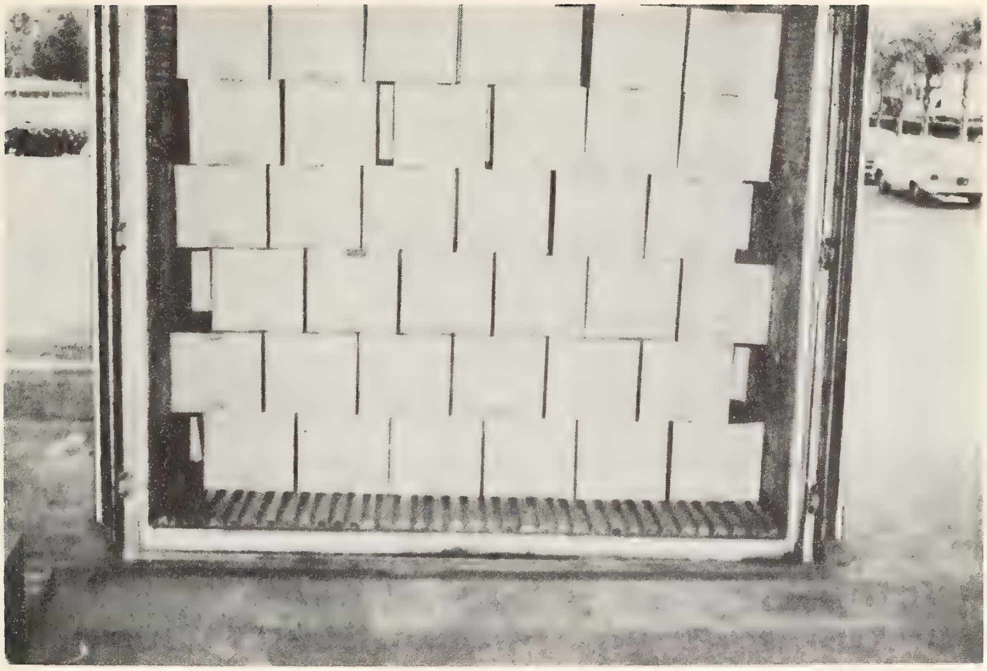
first layer were loaded across the trailer tightly against the bulkhead and against the first box and each other box so that there remained at the end of the layer a space between the last box and the trailer sidewall of a little less than one-half the width of a box. The second layer of the first stack was begun here with the first box resting partially over the space and partially on the last box of the first layer. The succeeding boxes of the second layer were placed tightly against the bulkhead and tightly against the first and each other box in the line, each box resting almost equally on the two boxes in the layer beneath, leaving a space at the end of the second layer of a little less than half the width of a box. The succeeding odd-numbered layers were loaded the same as the first layer and the succeeding even-numbered layers were loaded the same as the second. The boxes in the second stack were loaded by the same procedure except that loading of the second stack was commenced on the opposite side of the trailer from where the first stack had been started. The third, fifth, seventh, and other odd-numbered crosswise stacks were patterned after the first crosswise stack and the fourth, sixth, eighth, and other even-numbered stacks were constructed the same as the second crosswise stack. Under this procedure the open spaces at the end of the layers in one stack were offset by closed spaces (boxes) in the layers of the next stack because the loading of adjacent stacks, as explained, was alternated and begun at opposite sides of the trailer (fig. 8).

In Tests 30, 31, 32, and 34 it was found that this stacking procedure had considerably restricted the air circulation around and under these loads, or in some instances had almost completely cut it off. Also, in Test 31 (fig. 9) for example, the two rear stacks did not follow the crosswise offset principle and were loaded too tightly across the trailer from one sidewall to the other thus preventing any air circulation along the sidewalls. All four of the loads arrived at destination with the bottom two layers of the rear stack tightly against the rear doors further restricting the air circulation around the rear of the load to the grooved floors for return flow to the refrigerating unit intake at the front of the trailer.

There were no vertical wall strips on the trailer sidewalls nor lengthwise air channels through the loads in these four tests, and spaces between the rear of the loads and the rear doors had not been provided. As a result, heat transmitted through the walls of the trailer passed directly into the boxes as it penetrated the cargo area instead of being picked up by circulating cold air and returned to the refrigeration coil for removal. Due to restricted air circulation in the four test loads, some of the fruit in the boxes had picked up as much as 15 degrees or more in temperature during transit.

An attempt was made to increase the air flow in the load of Test 34 by loading the last three stacks with the boxes in identical positions in each stack to provide partial lengthwise air channels. However, as the preceding stacks were not uniformly loaded to conform with the last three stacks, it was not possible to have continuous air channels in the load from front to rear, and air circulation was blocked.

The entire load of Test 33 was loaded by the crosswise offset method without lengthwise air channels but, unlike Tests 30, 31, 32, and 34, it had a 12-inch space between the end of the load and the rear doors of the trailer.

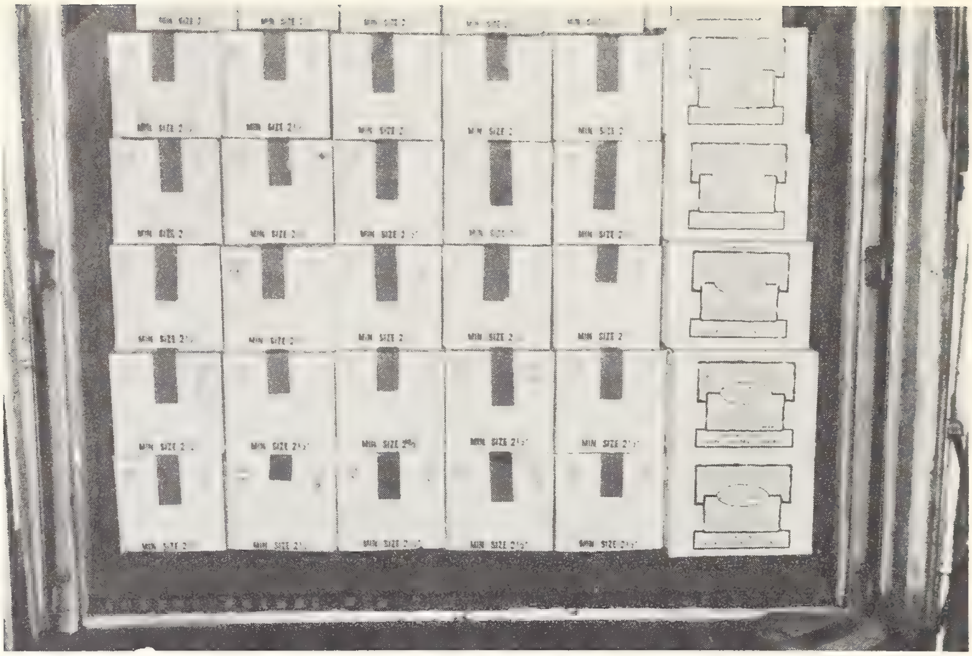


BN-7914

Figure 8.--Rear view of test shipment loaded crosswise offset by-stacks-and-layers in which air circulation along the sidewalls is blocked. Note that open spaces at sides of the layers of rear stack are blocked by closed spaces (boxes) in identical layers of the preceding stack.

This allowed more circulation of air around the commodity with a marked advantage in temperature over Tests 30, 31, 32, and 34. This advantage is apparent in table 3, which shows the fruit temperatures for Tests 30 through 35 at destination and for Tests 36 and 37 at both origin and destination. Even with the better temperature results in Test 33 there was still room for other improvements in the loading methods.

On the basis of the findings in Tests 30 to 34, it was decided to revise the crosswise offset loading on succeeding tests of apples from controlled-atmosphere storage in an attempt to improve air circulation in the loads. Therefore, three experimental tests, 35, 36, and 37, were loaded by the crosswise offset method, except that the boxes in all the crosswise stacks subsequent to the first crosswise stack were located in the same position in each stack as the boxes in the first stack. Thus continuous air channels were provided along the entire length of both sidewalls of the trailer (fig. 10). In addition, there were 2 inches of space between the end of the load and the rear doors of the trailer in Test 35, and 12 inches of space in both Tests 36 and 37. The trailer body used in Test 35 was also equipped with vertical wall strips on the sidewalls which extended from the floor to halfway to the



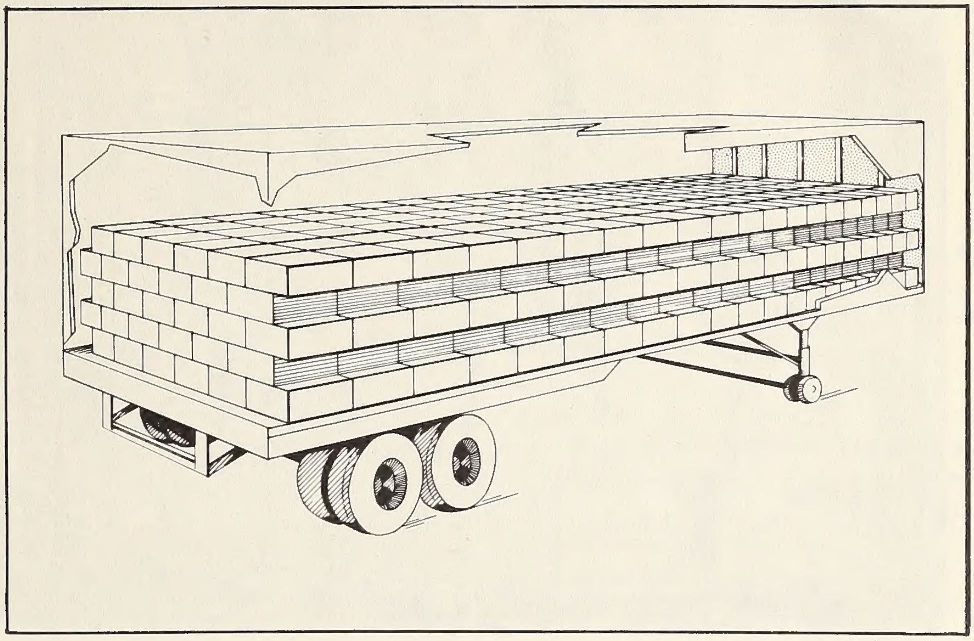
BN-7915

Figure 9.--Test shipment in which rear stacks of boxes are loaded so tightly and solidly across the trailer from sidewall to sidewall as to completely cut off air circulation along the sidewalls.

ceiling. These strips kept the loads from fitting too tightly against the walls and allowed additional air circulation space. Fruit temperatures were taken in various parts of the Test 35 load at destination only. They are shown in table 3.

The figures in parentheses in table 3 are the average temperature readings taken in the corner of boxes located tight against the plywood sidewall of the trailer. The average is taken from the readings for 3 or 4 sample boxes in the top, middle, or bottom layers of each test load. In each case, an apple in the corner of the box next to the trailer wall was checked because in that position the apple was subject to more heat infiltration than the apples in the interior of the box. In some instances the temperature of the corner apple was as much as 12 degrees higher than that of apples in the interior of the same box.

However, in the one experimental test shipment (35) with wall strips on the trailer walls, the corresponding fruit temperatures varied only a degree or two within the same containers. This emphasizes the need for wall strips (fig. 11) on the bunker bulkhead and sidewalls of the trailers to help provide better circulation of air for refrigeration. Stripping the rear doors of the trailers would be of additional benefit in this respect especially where the end of the load comes close to the doors.



BN-7916

Figure 10.--Side view of a load of apples in fiberboard boxes in a motortruck semi-trailer showing arrangement of containers in stacks and layers to provide air channels (shaded spaces) from front to rear of load for circulation of air, thus allowing more adequate refrigeration.

To measure the efficiency of the revised crosswise offset loading as related to air circulation more accurately, fruit temperatures were checked in specific locations of the air-channel loads in 36 sample boxes per load in Test 36 and in 42 boxes in Test 37 at both origin and destination. The results are given in table 3. It appears that the provision of proper air channels along the sides of the loads enables the maintenance of air circulation in transit to reduce appreciably the variation in the fruit temperatures between origin and destination. For example, based on all the locations at which temperatures were taken in Test 37, a mechanically refrigerated load with the thermostat set at 36° F., the lowest and highest readings at origin were 32° and 39°. The corresponding readings at destination were 37° and 42°. Thus the lowest temperature at destination was 5 degrees above the lowest temperature at origin and the highest temperature at destination was 3 degrees above the similar temperature at origin. The total range between the minimum temperature at origin and the maximum temperature at destination was 10 degrees. The lower temperatures in Test 37, with only small variations between origin and destination, resulted from proper circulation of the air in the trailer and, thus, the more effective removal of the heat coming through the trailer sidewalls before it could be absorbed by the apples.

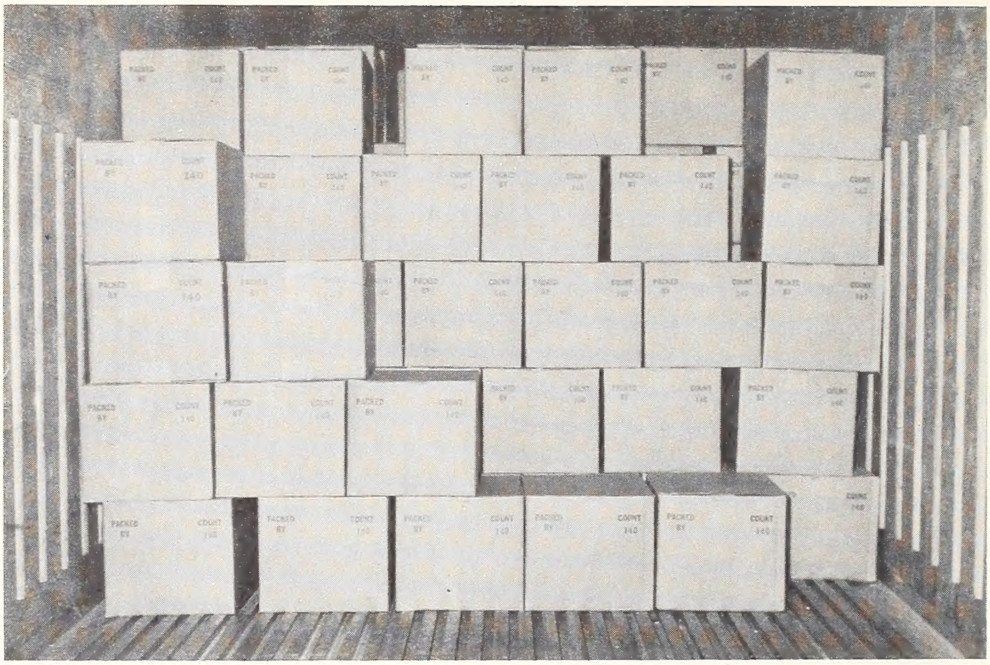


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Figure 11.--Interior of truck trailer equipped with sidewall strips which keep load from fitting too tightly against sidewalls, thereby permitting sidewall air circulation. The side strips shown here would have been more effective if they had extended higher.

Test 36 was the only test in the group of 8 shipments of controlled-atmosphere storage apples made in a trailer equipped with an ice bunker and a blower. The test trailer had only 1½ inches of insulation. Under the best conditions, and even if the trailer had been equipped with wall strips, water ice refrigeration could not have been expected to provide temperatures much lower than those shown in table 3 with the ambient temperature at close to 80° F. However, the accelerated circulation of air from the lengthwise air channels through the load resulted in the maintenance of temperatures in this trailer which compared favorably with the averages on earlier tests that moved under mechanical refrigeration but had inadequate circulation because of the blocking of the air channels by the loading method.

Another important consideration in connection with air circulation and maintenance of desirable fruit temperatures is the combined total size of the openings in the grooved floors of the trailers compared with the total area of the blower outlet on the refrigeration unit. For most of the test trailers, the total area of a cross section of all the grooves was approximately 42 square inches, whereas the blower outlet area was 240 square inches. Where the area of the grooves represents such a small ratio to the blower outlet area, it would have been more efficient to use floor racks in addition to the extruded aluminum floor than to depend entirely on the grooved floor for circulation under the load.

There were also several instances of trash and dirt which accumulated in the first 2 inches of the grooves at the front of the trailers. This restricted circulation back to the refrigeration coils and so reduced the effectiveness of the trailers' refrigeration units.

CONCLUSIONS

The motortruck shipping tests of New England McIntosh apples indicated that the method of loading apples in fiberboard containers in trailers is an important factor in reducing damage in transit and providing more effective refrigeration of the loads.

The use of containers of uniform size facilitates greater uniformity of loading pattern with safer and more compact loads and aids in reducing damage that occurs in transit. For example, the 13 test loads of apples from regular storage shipped during February and March 1958 had container damage of 2.7 percent. In the 8 test loads of controlled-atmosphere apples originating in April and May 1958, in which boxes of uniform outside dimensions were used, such damage was reduced to only 0.9 percent of the total containers shipped.

Load patterns which contain air channels the entire length of the load seem to permit better refrigeration and maintain more uniform fruit temperatures in transit. In experimental Test 37, one of the shipments of controlled-atmosphere apples which was loaded to permit proper air channels, the lowest temperature was 32° at origin and 37° at destination and the highest was 39° at origin and 42° at destination. This compared with temperatures as high as 50° to 60° or above in test loads without air channels. Additional experimental test loads will be necessary to determine more conclusively the effectiveness of the air-channel loading method in reducing transit damage and in improving the refrigeration of the fruit in transit and to develop any further refinements in it that may be required.

Closer supervision of loading of the trailers by the shipper and more systematic arrangement of the shipper's loading orders to the truck drivers would help in achieving greater uniformity of loading patterns, better loading practices, more efficient handling of the boxes with less damage, and reduced loading time.